

Effectiveness and Cost Comparison

Specialist Report

East Fork Boulder Creek Native Trout

Restoration Project

USDA-Forest Service-Dixie National Forest

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This analysis will address the effectiveness and provide a cost comparison of the alternatives for the proposed East Fork Boulder Creek Native Trout Restoration project. The analysis is based on the No Action, Proposed Action, and Non-Chemical Treatment alternative, including actions that are not part of the Forest Service decision but connected to the project, as described in Appendix 1.

Analysis of effectiveness addresses how well the alternative meets the objective of the proposed project, i.e. eradication of non-native trout from the treatment area. Cost of treatment in terms of dollars and effort is provided for comparison across alternatives.

No Action

The No Action alternative would result in no activities to remove nonnative trout from the treatment area. It would not meet the objective of the proposed project.

Because no actions would be taken, no costs would be incurred.

Proposed Action

Effectiveness

The Proposed Action would result in a treatment involving rotenone. Rotenone has been shown to be effective at eradicating nonnative trout (Demong 2001, Hamilton et al. 2009, Finlayson et al. 2010). Meronek et al. (1996) found that chemical renovation projects were more successful than mechanical removal projects (58% to 43%) at reducing the abundance of target species; however, the goals of many of these projects were to simply alter population numbers, not completely remove species. The success of stream rotenone renovations to remove nonnative trout for native trout restoration in the Utah Division of Wildlife Resource's (UDWR) Southern Region has been considerably higher (Hepworth et al. 2001a, Hepworth et al. 2001b, Hepworth et al. 2001c, Ottenbacher and Hepworth 2001, Chamberlain and Hepworth 2002a, Chamberlain and Hepworth 2002b, Chamberlain and Hepworth 2002c; Table 1).

Of 26 stream rotenone renovations completed for native trout restoration since 1977, only one, West Fork Deer Creek, was completely unsuccessful. During the first treatment of this stream, UDWR recognized that the complexity of the stream substantially reduced the odds of successful eradication of brook trout and abandoned the project. Three projects required additional treatments over those initially planned to completely eradicate brook trout. One of the three was an early project (1979) that only used a single treatment. Since that time UDWR has recognized that generally two full treatments are needed to ensure complete eradication of the target species. Center Creek and U-M Creek required additional consecutive treatments for complete removal, but this need was recognized immediately and the treatments implemented consecutively. Four of the 26 projects (15%) have had reinvasions of nonnative fish

following barrier failure or unauthorized fish movements. Conversely, five of the treatments remained free of nonnatives for 20 years or more, and six have remained free of nonnatives for 15 years or more.

Where nonnative trout have been completely removed using rotenone in the Escalante River Basin, the standing crop of reintroduced or expanded Colorado River cutthroat trout (CRCT) populations has increased. Where CRCT populations were not present prior to nonnative trout removal, reintroduced populations have reached standing crops similar to CRCT populations in the absence of nonnative trout within 4-6 years after the rotenone treatment (Hadley et al. 2008). Two of the current CRCT populations in the Escalante River drainage were truly sympatric with nonnative trout prior to restoration activities. Both populations saw large increases in standing crop (350% in West Branch Pine Creek and 138% in White Creek) after nonnative trout removal.

Within the Boulder Creek drainage itself, West Fork Boulder Creek was treated in 2000-2001, and no brook trout have been collected within the treated reach since that time (Hepworth et al. 2001b, Hadley et al. 2008, Williams and Hardy 2010). CRCT standing crop in the treated area quickly rose to the levels seen in untreated areas upstream and has remained at those levels (Hadley et al. 2008, Williams and Hardy 2010). Similarly, no brook trout have been found in Short Lake since it was treated in 2007 to remove a stunted nonnative brook trout population and establish a CRCT fishery (Hadley 2010). Sampling of Short Lake in 2010 showed that the catch rate for CRCT was above average when compared to other southern Utah trout lakes and that CRCT were longer, heavier and in better condition than the brook trout that were present when the lake was sampled in 1982 and 1999 (Hepworth and Beckstrom 2004, Hadley 2010).

Cost and effort

East Fork Boulder Creek is complex and will require a large amount of effort to treat. The September 2009 treatment of East Fork Boulder Creek and inflows from the headwater meadow down to and including King's Pasture Reservoir, along with treatment of the private pond in King's Pasture used 31 personnel for 1.5 to 3 days for a total of approximately 56.5 man days (Ottenbacher et al. 2009). The manpower plus materials costs totaled approximately \$22,300. The reach from King's Pasture Reservoir downstream to the fish barriers is longer but less complex and with less flow volume; therefore, a conservative estimate of cost for treating this lower reach is the same cost as the 2009 treatment of the upper reach. If two treatments are successful at eradicating nonnative trout in the entire area, then the total estimated cost of the project would be just under \$90,000. There would also be costs associated with transportation vehicles for the crews. The chemical dispensing equipment may also incur a cost, but would likely already be available.

Table 1. Utah Division of Wildlife Resources stream chemical renovation projects for native trout restoration in Utah's Southern Region. Under "Status": S = fully successful (non-native fish eradicated, native fish re-established), S' = fully successful but follow-up management was required, U = unsuccessful

Stream	Treatment dates	Status	Comment
Bonneville cutthroat trout			
Sam Stowe Creek	1977, 1997	S'	Retreated after barrier failure / reinvasion
Pine Creek (Sevier R)	1979, 1986	S'	Required 2 nd unplanned treatment
Threemile Creek	1993, 1994	S	Nonnative trout removed below barrier by electrofishing
DeLong Creek	1993, 1994	S	
Indian Hollow	1993, 1994	S	
North Fork North Cr	1992, 1999	S'	Partially retreated after barrier failure
Pole Creek	1992	S	
Manning Creek	1995, 1996 2001	S'	Partially retreated following inadvertent or illegal stocking
Barney Creek	1995, 1996	S	
Vale Creek	1995, 1996	S	
E. Manning Cr	1995, 1996	S	
Birch Cr (Sevier R)	2001	S	
Tenmile Creek	2001, 2002	S	
Center Cr / Robs Res	2002-2004	S'	3 treatments required for complete removal
Leap Creek	1985	S	Later extirpated by fire
South Ash Creek	1985	S	Later extirpated by fire
Leeds Creek	1989	S	
Colorado River cutthroat trout			
West Deer Creek	1994	U	Project discontinued after complete removal deemed unrealistic following initial treatment
West Boulder Creek	2000, 2001	S	
Pine Cr (Escalante R)	2001, 2002	S	
Whites Creek	2000, 2001	S	
Twitchell Creek	2001, 2002 2006	S'	Partially retreated after barrier failure
U M Creek	1992-1995	S'	4 treatments required for complete removal; May require stocking to maintain
Pine Cr (Fremont R)	2002, 2003	S	

Non-chemical Treatment Alternative

Effectiveness

Efforts to completely eradicate nonnative fish by non-chemical methods in streams, rivers, lakes, and reservoirs have generally been unsuccessful (Lentsch et al. 1996, Meronek et al. 1996, Thompson and Rahel 1996, Tyus and Saunders 2000, Golden and Holden 2002, Mueller 2005, Koel et al. 2005, Meyer et al. 2006, Caudron and Champigneulle 2010, Koel et al. 2010). Specifically, electrofishing efforts to remove nonnative trout from streams have met with variable success. Several efforts to remove brook trout from small streams (< 3.0 m wide) in the western United States and Canada have been successful at significantly reducing brook trout numbers but have not been successful eliminating them completely (Thompson and Rahel 1996, Buktenica et al. 2000, Peterson et al. 2004, Meyer et al. 2006, Birchell 2007, Earle et al. 2007, Firehammer et al. 2009, Carmona-Catot et al. 2010). Stream size (length, width, and volume) and complexity, ability of brook trout to begin reproducing by age 1, inability to increase removal effort because of funding or timing considerations, and inability to conduct piscicide treatments were offered as reasons for the inability to eradicate brook trout.

A few studies have shown that nonnative trout can be successfully eradicated under certain conditions (Moore et al. 1986, Kulp and Moore 2000, Sheppard et al. 2002, Moore et al. 2005). The majority of these examples are from streams in Great Smoky Mountains National Park, where removal of nonnative rainbow trout to restore native brook trout populations has been ongoing since 1976 (Moore et al. 1986, Kulp and Moore 2000, Moore et al. 2005). Initial efforts focused annual electrofishing removal in four streams (0.1 km – 1.5 km in length) over six years. Rainbow trout abundance was significantly reduced but not eliminated during that time; however, ten years later the streams were reevaluated and two of the four were found to be free of rainbow trout (Moore et al. 1986, Moore et al. 2005). Similarly, rainbow trout were successfully removed from 0.9 km of stream after four removal passes in one year and two removal passes in the second year (Kulp and Moore 2000). In addition to the intensity and duration of removal efforts, the authors concluded that habitat simplicity aided in the complete eradication of rainbow trout. Rainbow trout persisted in at least five streams where long-term removal projects were conducted. Moore et al. (2005) indicated that complete eradication in streams wider than 4.5 m and/or with complex habitats (4 or more pools > 1 m deep per km) was nearly impossible to achieve through electrofishing removal. Multiple electrofishing removal attempts on a stream displaying those characteristics were unsuccessful at eradicating rainbow trout. Moore et al. (2005) determined that the stream was too complex for mechanical removal and eventually used a piscicide to successfully eradicate rainbow trout from a 4.8 km section of that stream.

In the western United States, Shepard et al. (2002) successfully removed brook trout from 4.8 km of a native Westslope cutthroat trout stream using electrofishing removal over an 8 year period. They removed brook trout using a combination of single and multipass removal methods and varied their efforts between single and multiple removals annually. In addition to electrofishing they constructed an immigration barrier, drained stream side ponds that were supplying brook trout to the system, and trimmed back overhanging vegetation to increase their efficiency. They attributed much of their success to the small size of the stream (2 m wide) and the lack of complex habitat.

Shepard (2010) was also successful in eradicating brook trout from 2.5 to 3.0 km treatment reaches of four streams using multiple pass electrofishing. The streams were 1.4 m to 2.6 m wide with late summer discharges between 2.1 cfs and 6 cfs. Complete eradication took anywhere from 4 to 8 years. The number of treatment efforts each year and the number of passes during each treatment effort varied among streams; however, it took between 13 and 29 total passes (the sum of treatment efforts*passes during each treatment effort) to completely eliminate brook trout. Shepard (2010) was unsuccessful at eradicating brook trout from two other streams because of dense overhanging vegetation and large amounts of instream cover. He concluded that the efficiency of nonnative fish removal is reduced by increasing stream size, increasing amounts of overhanging and instream cover, the presence of deep pools, and the presence of beaver ponds. He recommended planning for at least six treatments of two to three passes per treatment in order to achieve complete eradication.

Conversely, Thompson and Rahel (1996) were not able to completely remove brook trout from three relatively small streams (average width ≤ 1.6 m) using a single year of 3 pass electrofishing removal, followed by a second year of single and multiple pass removal efforts. Buktenica et al. (2000) used multiple mechanical removal methods over five years (electrofishing, snorkel-directed electrofishing, trap-netting) in an attempt to remove brook trout from bull trout habitat. They were able to almost completely remove brook trout from a short length (3.4 km) of the headwaters of their study area (average width ≤ 1.5 m), which had a low density of brook trout, but they could not mechanically eradicate brook trout from downstream sections that had similar length (5.1 km and 3.1 km), higher brook trout density, and increased stream size (width 3m – 6m). Eventually they used the piscicide Antimycin to eradicate brook trout from the lower sections.

Similar to Thompson and Rahel (1996), Carmona-Catot et al. (2010) found that they were able to reduce significantly but not eliminate brook trout from a small stream (2.1 km, 1.2 m wide, 0.6 cfs). They completed 3 pass removal efforts once a year for three years and found that they were able to suppress, but not eliminate recruitment. They also found that the condition, growth, and fecundity of the remaining brook trout increased, indicating a compensatory response to the reduction in density. Carmona-Catot et al. (2010) concluded that complete elimination of brook trout in their small

study stream may have been possible with additional effort; however, they felt that in larger streams, with lower capture efficiencies, complete elimination was much less likely.

Earle et al (2007) found that unlimited angling harvest by trained anglers for eight combined with single pass removal electrofishing efforts for three years suppressed brook trout density and standing crop, but not to a level below those of the bull trout and westslope cutthroat trout populations targeted for benefit. Additionally, no appreciable response in bull trout or westslope cutthroat trout standing crop was in observed in response to the removal efforts. Firehammer et al. (2009) attempted to suppress brook trout numbers using single pass electrofishing in 2.9 to 11.7 km of stream for the benefit of resident westslope cutthroat trout. Over a four year period they were unable to detect a significant decline in brook trout density; however, they did note a positive response in westslope cutthroat trout populations. Since physical stream restoration was occurring within the same watershed, the positive response could not be directly tied to the brook trout removal efforts.

Birchell (2007) attempted to mechanically remove brook trout from a 12.1 km stretch of stream with an average wetted width of 3.2 m and baseflows of approximately 5 cfs using multiple pass removal electrofishing. He conducted a total of nine removal passes between 2003 and 2005 (four in 2003 and 2004 and one in 2005). They estimated that they had removed more than 80% of the brook trout population after the 2003 and 2004 efforts, but had not eliminated reproduction and recruitment. While Birchell (2007) did not achieve complete eradication of brook trout, the CRCT population in the stream showed improved growth, body condition, and an apparent increase in recruitment and mobility; however, as in the Earle et al. (2007) study population abundance did not increase in response to the removal efforts. He concluded that "the complete eradication of brook trout via depletion removal electrofishing from streams similar in size and habitat complexity...would be nearly impossible to achieve."

East Fork Boulder Creek is a relatively large, complex stream when compared to streams where electrofishing removal has been effective. Approximately 13.7 km of stream are slated for removal efforts under the proposed project. Average wetted widths at fish survey sites from the headwater meadow downstream to King's Pasture Reservoir ranged from 3.5 m to 6.4 m during fisheries surveys above Kings Pasture Reservoir, while average widths ranged from 2 m to 3.3 m throughout the remainder of the project area (Hadley et al. 2008, Williams 2010). Baseflows in the project area vary from 2 cfs to 21 cfs (FERC 2007). The project area on East Fork Boulder Creek is longer and generally wider than streams where successful electrofishing removal projects have occurred. Additionally, the habitat in a large portion of the project area is complex with deep riffles and cascades, as well as deep (> 1 m pools), undercut banks, and abundant instream cover. Data from previous mechanical removal projects

indicates that achieving complete eradication through electrofishing removal in the proposed project area will be difficult, if not impossible. Additionally, brook trout in King's Pasture Reservoir would have to be eradicated simultaneously, or prior, to the stream removal efforts. A barrier would have to be maintained between the reservoir and the stream to prevent immigration and emigration between systems.

Removing brook trout from King's Pasture Reservoir and the pond in King's Pasture also presents a challenge. Mueller (2005) found that an intensive 5-day trammel net effort in a 3.2 acre backwater along the Colorado River removed about 58% of the warmwater predators. Meronek et al. (1996) found that 37% of netting removal projects they reviewed were not able to produce a measurable reduction in the target species. Koel et al. (2005) and Koel et al. 2010 document an intensive netting removal effort for lake trout on Yellowstone Lake. After 12 years, lake trout abundance continued to increase, despite removal hundreds of thousands of lake trout. Conversely, Knapp and Matthews (1998) and Parker et al. (2001) both were able to eliminate brook trout from small (4 to 5 acre, 6 to 9 m maximum depth) mountain lakes. Knapp and Matthews (1998) suggested that mechanical removal was unlikely in lakes large than 4.5 acres, greater than 10 m in depth, with outflows wider than 0.5 m, inflows wider than 1 m, or stream spawning areas larger than 1 sq m. Parker et al. (2001) felt that the use of more, larger nets could successfully eradicate brook trout from lakes as large as 25 acres; however, they cautioned the lakes with inflows and outflows would need to have barriers erected at the outflow and nonnative fish removed from the inflow before mechanical removal would be effective at eliminating brook trout.

The pond in King's Pasture has a surface area of approximately 1.5 acres and a maximum depth of 1.5 m. The pond in King's Pasture appears to satisfy all the parameters necessary for a successful mechanical removal. While it has an inflow and outflow, both are small and no evidence of reproduction or recruitment was evident during the September 2009 piscicide treatment of that pond. Based on previous studies it will probably take at least two years to remove brook trout from the pond in King's Pasture using non-chemical methods. Electrofishing removal in East Fork Boulder Creek would not be able to be completed until this pond is free of brook trout.

King's Pasture Reservoir has a surface area of approximately 2.5 acres and a maximum depth of approximately 5.5 m and may fit within the size criteria thought to be amenable to complete removal through non-chemical methods; however, East Fork Boulder Creek is the inflow for the reservoir. Above the reservoir East Fork Boulder Creek is approximately 3.5 – 4.0 m wide, which is considerably wider than the 1 m specified by Knapp and Matthews (1998) as a criteria for successful brook trout removal. Additionally, a large amount of spawning habitat for nonnative brook trout exists above the reservoir, as evidenced by the large number of young-of-year and juvenile brook trout previously found in fish surveys of this area (Hadley et al. 2008, Hardy et al. 2009a, Hardy et al. 2009b). Brook trout would have to be eradicated from

the stream prior beginning removal efforts in the reservoir, in order for those efforts to be successful; therefore, a barrier would have to be maintained between the reservoir and the stream to prevent immigration and emigration between systems.

Cost and effort

In order to complete 4 removal passes on the Forest lands included in the proposed project and non-Forest lands connected to the proposed project during one accessible season, approximately 20 people (4 crews) would be necessary for one removal effort. Each removal effort would take approximately 20 days totaling approximately 80 days per year for four removal efforts or 1600 people days per year (20 people X 20 days/effort X 4 effort/yr = 1600 people days/yr). Based on a cost estimate provided by Utah State University's Institute for Natural Systems Engineering, the estimated cost for conducting four removal efforts in the mainstem Boulder Creek in would be approximately \$443,776 in labor (Williams 2010). Using the person day rate for UDWR during the 2009 rotenone treatment of East Fork Boulder Creek produces a slightly lower but similar estimate of \$416,000 in labor (Ottenbacher et al. 2009). An additional, but unknown amount of effort and labor cost will be necessary to eradicate brook trout from the spring inflows and tributaries on both Forest and non-Forest land.

In addition to the effort for the flowing portions of the stream, effort will be needed to remove nonnative trout from King's Pasture Reservoir and the pond on private property. Knapp and Matthews (1998) set and pulled nets 18 times the first year of their study. For a two person crew that would be 36 person days, or approximately \$9,360 at the UDWR person day cost.

A final cost associated with the alternative is the construction of at least one fish barrier above King's Pasture Reservoir. A loose rock barrier would cost approximately \$2,000 to construct (Ottenbacher 2010). Without accounting for the extra cost of removing nonnative trout from springs and tributary inflows, the cost of labor for removing nonnative trout from all water bodies connected to the proposed project and the construction of the fish barrier would cost approximately \$427,000 during the first implementation year. Previous studies suggest at least one more year of similar effort would be necessary to completely eradicate nonnative trout, bringing the total cost just for removal labor and the construction of the fish barrier to approximately \$852,000. The additional labor to remove nonnative trout from springs and tributaries affiliated and connected to the proposed project would probably bring the costs to well over \$1,000,000. There would also be higher vehicle costs than under the Proposed Action because of the higher number of people that would be needed, along with costs for equipment, although most of the equipment is expected to be available.

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Appendix 1. Project Area and Alternatives Analyzed in Detail

The following describes and compares the Forest Service alternatives analyzed. It includes a description of the UDWR's proposed project and considers UDWR's treatment alternative in detail. This section also presents the alternatives and the UDWR activities that would be authorized or connected actions to the alternatives in comparative form.

Project Area

The proposed East Fork Boulder Creek Native Trout Restoration Project (project) is located approximately 7 miles northwest of Boulder, Utah (see Figure 1). The total treatment area is as follows:

- approximately 7.8 miles (12.6 km) of East Fork Boulder Creek from the natural barrier (below headwater meadow) on East Fork Boulder Creek to its confluence with West Fork Boulder Creek;
- approximately 0.2 miles (0.4 km) of lower West Fork Boulder Creek, from a previously constructed barrier to its confluence with East Fork Boulder Creek;
- approximately 0.5 miles (0.8 km) of Boulder Creek from the confluence of East Fork Boulder Creek and West Fork Boulder Creek downstream to a previously constructed fish barrier;
- all seeps and springs flowing into those sections of streams proposed for fish removal; and
- the Garkane Energy water transfer pipeline between the West Fork Reservoir and King's Pasture Reservoir; King's Pasture (East Fork) Reservoir; a pond on private property in King's Pasture, and the Garkane Energy penstock, between King's Pasture Reservoir and the Garkane Energy Boulder Creek Hydroelectric Power Plant (main power plant).

The treatment stream reaches flow through portions of Sections 27, 28, 33, and 34 of T31S, R4E, and Sections 3, 10, 15, 21, 22, and 28 of T32S, R4E, Salt Lake Baseline Meridian. Treatment would include connecting waters, including relatively large inflows or tributaries with permanent fish habitat and smaller springs and seeps that are capable of at least temporarily holding small fish. Known tributaries and inflows vary in length from 10 meters to over 750 meters.

The reaches on NFS-lands are all on the Escalante Ranger District of the Forest in Garfield County, Utah. The inflow of the water transfer pipeline is at the West Fork Reservoir in Section 8, T32S, R4E, and the outflow is at King's Pasture Reservoir in Section 10 of T32S, R4E. The inflow of the penstock is at King's Pasture Reservoir, and the outflow is at the main power plant in Section 35 of T32S, R4E.

No Action- No Further Treatment Scenario

Under the No Action alternative, the Forest would not approve the pesticide use permit to UDWR, would not authorize UDWR to use motorized vehicles off of designated routes for the application of rotenone to waters of the treatment area on NFS lands, and would not approve a special use authorization for UDWR to bury removed fish.

The No Action alternative would not preclude UDWR from implementing actions on NFS lands that would meet the purpose and need for UDWR's project but do not require Forest Service authorization. This includes UDWR activities described under the Non-chemical Treatment alternative (Section 2.1.3) except for the use of motorized vehicles off of designated routes or burial of removed fish on NFS lands. The No Action alternative would also not preclude UDWR from implementing actions on non-NFS lands that are related to the purpose and need for UDWR's project but not under Forest Service jurisdiction or authorization.

One possible option for UDWR is to take no further action to meet the purpose and need of the proposed project. This possible option is identified in this analysis as the "No Action - No Further Treatment Scenario" and is the basis for the effects analysis for the No Action alternative to provide the base line for comparison of expected future conditions if neither the Proposed Action nor Non-chemical Treatment alternative were implemented by the Forest and UDWR were to take no further action to meet the purpose and need.

Proposed Action

The Proposed Action is to approve the pesticide use permit that the Forest Service requires the UDWR to have to apply the fish toxicant rotenone to waters that flow on NFS lands and to authorize motorized vehicle use off of designated routes. The pesticide use permit would authorize the UDWR to implement a maximum of three treatments on NFS land, one treatment per year for three consecutive years. Waters on NFS land that would be treated by UDWR under the Forest Service pesticide use permit are as follows:

- approximately 7.8 miles (12.6 km) of East Fork Boulder Creek from the natural barrier (below headwater meadow) on East Fork Boulder Creek to its confluence with West Fork Boulder Creek;
- approximately 0.2 miles (0.4 km) of lower West Fork Boulder Creek, from a previously constructed barrier to its confluence with East Fork Boulder Creek;
- approximately 0.5 miles (0.8 km) of Boulder Creek from the confluence of East Fork Boulder Creek and West Fork Boulder Creek downstream to a previously constructed fish barrier; and
- all seeps and springs flowing into those sections of the stream reaches specified in the permit.

The UDWR activities that would be authorized by the Forest under the Proposed Action would completely eradicate non-native trout from East Fork Boulder Creek, a short segment of Boulder Creek, and a very short segment of West Fork Boulder Creek. All fish would be temporarily eliminated by UDWR from target waters. Use of motorized vehicles by UDWR off of designated routes may be needed to facilitate placement of equipment, especially neutralization equipment, in effective locations.

Several actions that are not part of the Forest Service decision are connected to the UDWR project, as follows. UDWR is proposing chemical treatment of connected waters on private property to meet the purpose of the UDWR project. Following fish removal, UDWR would introduce the CRCT into the treated stream segments to establish self-sustaining populations. Sterile hybrids of species of non-native trout

may also be stocked by UDWR at some locations following the treatments to provide sport fishing opportunities while native trout become established. The following describes the UDWR project in detail, including identification of those actions that do not require Forest Service authorization.

Chemicals. Liquid emulsifiable rotenone (Liquid Rotenone, 5% Active Ingredient, EPA Registration No. 432-172) would be used by UDWR to treat target waters. Rotenone was selected as the chemical to use because of its effectiveness in controlling fish populations and its lack of long-term effects on the environment (Sousa et al 1987). When used at the concentrations planned for the UDWR project, rotenone is a naturally occurring fish toxicant that is toxic to only fish, some aquatic invertebrates, and some juvenile amphibians. EPA found it to be not toxic to humans, other mammals, and birds at the concentrations used to remove fish (EPA 2007). It has been widely used in the United States since the 1950's. UDWR has used rotenone successfully in many similar projects and has refined application techniques to minimize adverse side effects to the environment (Hepworth et al. 2001a, Hepworth et al. 2001b, Hepworth et al. 2001c, Ottenbacher and Hepworth 2001, Chamberlain and Hepworth 2002a, Chamberlain and Hepworth 2002b, Chamberlain and Hepworth 2002c, Fridell et al. 2004, Fridell et al. 2005, Fridell and Rehm 2006).

Potassium permanganate would be used by UDWR to neutralize the rotenone at suitable locations to prevent the movement of rotenone into non-target waters. Potassium permanganate was selected, because it is a strong oxidizer that breaks down into potassium, manganese, and water. All are common in nature and have no deleterious environmental effects at the concentrations that would be used for the UDWR project activities, including those that would be authorized by the Forest under the Proposed Action (Finlayson et al. 2000). Potassium permanganate is used as an oxidizing agent in treatment plants to purify drinking water (EPA 1999). Although the oxidation process is not immediate, neutralization should occur within an estimated 0.25 to 0.5 miles of the neutralization site.

A more detailed description of the chemicals that would be used for the UDWR project activities, including those that would be authorized by the Forest under the Proposed Action, can be found in specialist report on Chemicals and Application of the Proposed Action.

Application. Liquid rotenone would be applied by UDWR at a rate of 0.5 to 2.0 ppm. In the pond and reservoir, liquid rotenone would be dispersed from personnel on small water-craft using pressurized backpack spray units. For flowing waters, seeps, and springs, liquid rotenone would be applied using a combination of 30 gallon and 5 gallon dispensers with constant flow drip-heads at approximately 50 to 60 stations throughout the UDWR project area over a 3 to 24 hour period (Finlayson et. al 2000, Ottenbacher et al. 2009). One 30 gallon drip station would be used by UDWR at each at the following:

- lower end of the headwater meadow at the upstream end of the UDWR project area,
- approximately halfway between the headwater meadow and King's Pasture Reservoir,
- immediately below King's Pasture Reservoir, and
- at the intake for the water flow pipeline between the West Fork Reservoir and King's Pasture Reservoir.

Five-gallon drip stations would be located by UDWR at approximately 1 mile intervals, beginning one mile below King's Pasture Reservoir and ending 1 mile upstream from the fish barriers on the main stem

of East Fork Boulder Creek, and at all major springs and seeps within the UDWR project area. The interval placement of drip stations on the main stem of East Fork Boulder Creek would be to facilitate efficient travel time of chemicals. Depending on flow volume, a single 30 gallon or 5 gallon drip would be placed by UDWR on the lower fish barrier on West Fork Boulder Creek. Pressurized backpack sprayers would be used by UDWR to apply a diluted solution of the chemical to springs and backwater areas containing fish that were not effectively treated by boat or drip station.

Rotenone would be neutralized by UDWR with potassium permanganate downstream from target waters. Three sites are planned: where the penstock water is released at the upper power plant, where water is released at the main power plant, and at the fish barrier at the lower end of the treatment area. Each site would have a main neutralization station and at least one contingency neutralization station to ensure effectiveness. The neutralization stations would prevent rotenone from escaping the target area, except for the estimated 0.25 to 0.5 miles downstream in which the neutralization or natural degradation of rotenone would be occurring.

Post-treatment activity. Following confirmation of complete non-native trout removal, UDWR would reintroduce CRCT into project stream reaches from “core” CRCT populations or from fish produced by UDWR CRCT brood stocks. Sterile hybrids of species of non-native trout may also be stocked by UDWR at some locations following the treatments to provide sport fishing opportunities while native trout become established. All UDWR transfers or stocking of fish would comply with Utah Department of Agriculture and Food rules and UDWR policies.

Design Criteria. The following design criteria would be implemented and included in the Forest Service authorizations:

1. Stream sections will be treated in the fall to minimize impacts on non-target wildlife species (amphibians, insectivorous birds and bats). The fall treatment period will also minimize the impacts on sport fishing recreation.
2. Each treatment will be preceded by internal and external notifications and media releases to notify the public of treatment sites and dates and will include the following: notification of the Boulder Town Council, notification of private landowners in the treatment area, and news releases in local papers.
3. The treatment area will be placarded to prohibit public access during treatment and for at least 3 days following treatment.
4. Application of the chemical will be conducted by licensed pesticide applicators in accordance with all applicable regulations and policies.
5. Access by motorized vehicles will be on National Forest System roads designated for motorized vehicle use to the extent possible. Any use of motorized vehicles off of designated routes will be minimal and will require written Forest Service approval.
6. Neutralization sites will be placed to maximize their effectiveness at preventing downstream escapement of rotenone.
7. Treated waters will remain open to fishing.

8. Transport to the site and storage of chemicals on the site will comply with FSH 2109.14.40 (Pesticide-Use Management and Coordination Handbook, Chapter 40 - Storage, Transportation, and Disposal).
9. Sentinel fish (“in situ bioassay”) will be used for pesticide residues monitoring to determine the presence or absence of unacceptable environmental effects.
10. Treatments will be discontinued if the objective of complete removal of non-native trout from the project area has been met.

Actions connected to but not included in the decision. The following parts of the UDWR project, as described above, are not subject to Forest Service permit requirements, and therefore are not included in the Forest Service decision. Selection of the Proposed Action is for issuance of the pesticide use permit for the application of rotenone on NFS lands only. The following, however, are considered connected actions and thus included in the environmental analysis:

1. The proposed UDWR treatment area includes private property, including property owned by Garkane Energy; thus, this area is not under Forest Service jurisdiction. This includes approximately 1.4 miles of East Fork Boulder Creek, Kings Pasture Reservoir, and the pond in Kings Pasture. To meet the purpose and need of the UDWR project, these areas as well as the water in the transmission pipeline and penstock must be treated by UDWR. Forest Service approval of the pesticide use permit for UDWR to apply rotenone to waters on NFS land is not approval of UDWR activities on non-NFS lands; however, the Forest Service would not approve the pesticide use permit unless UDWR is able to complete its project by treating waters off of NFS land.

The expectation is that the entire UDWR project treatment area would receive chemical treatment as described below, although the UDWR may decide to use another method or methods to achieve the treatment objective. FERC license order Section 4(e), item 16, condition 4, requires Garkane Energy to use its reasonable efforts to cooperate in the work of UDWR and other agencies to remove non-native fish and re-establish CRCT in the above stream sections. This cooperation has already been demonstrated through construction of the fish barriers and through the first chemical treatment of Kings Pasture Reservoir in 2009.

2. Stocking of fish is under the jurisdiction of UDWR; thus, the CRCT stocking is not under Forest Service jurisdiction. To meet the purpose and need of the UDWR project, the stream would need to be stocked by UDWR with CRCT from core populations or UDWR brood stock post-treatment.

The expectation is that the post-treatment recolonization/stocking of CRCT would occur as described. The purpose and need for the UDWR project, including stocking with CRCT, is to implement conservation actions under the CRCT Conservation Agreement and Strategy, to which UDWR is a signatory. In addition, the Forest Service conditions regarding the non-native fish eradication and fish restocking were included in a 2006 settlement agreement relating to the FERC license conditions and signed by Garkane Energy, Forest Service, and UDWR.

3. Fishing regulations, including whether or not treated waters would remain open to fishing, is under the jurisdiction of UDWR.

The expectation is that UDWR would manage the fishing regulations to meet the conservation actions under the CRCT Conservation Agreement and Strategy. UDWR recognizes the importance of the area to recreation users. Because of this, UDWR may also stock sterile hybrids of species of non-native trout at some locations following the treatments while native trout become established.

Non-chemical Treatment Alternative

Under the Non-chemical Treatment alternative, the Forest Service would authorize UDWR to use motorized vehicles off of designated routes and approve a special use authorization for UDWR to bury fish that are removed as necessary to implement a non-chemical treatment to remove non-native trout from waters on NFS land.

The non-chemical treatment methods would not involve the use of rotenone or other pesticides on NFS lands and, therefore, would not require Forest Service approval. The effects of the non-chemical treatment are being analyzed, because this option may be exercised by UDWR in the event that the Forest Service were to choose not to authorize pesticide use, and the approach would be a connected action to the authorization of the use of motorized vehicles off of designated routes and approval of a special use authorization for burial of removed fish. The other connected actions that would also not require new Forest Service action are described below. UDWR's non-chemical treatment and other connected actions may or may not occur under the No Action alternative if the UDWR were to use motorized vehicles only on designated routes. These UDWR actions also may or may not occur under the Proposed Action.

Under the Non-chemical Treatment alternative, UDWR would use electrofishing to remove non-native trout from the treatment waters on NFS lands. Except for possible motorized vehicle use off of designated routes and burial of removed fish, this alternative would not require Forest Service authorization.

Treatment area. The treatment area would remain the same as described in the Proposed Action.

Methodology and Equipment. Electrofishing would be used by UDWR to remove non-native trout from the treatment area on NFS lands. Electrofishing introduces an electric current into the water and is commonly used as a fish removal method. The electricity causes an involuntary muscle contraction in the fish, attracting them toward the source of the electricity (electrode). Workers with long-handled nets then collect the stunned fish. Voltage, amperage, pulse frequency, and waveform are manipulated to maximize effectiveness, which can be influenced by water flow and velocity, temperature, clarity, conductivity (dissolved mineral content), and substrate. Other factors influencing effectiveness include the fish size, species and behavior, presence of aquatic vegetation, time of year, and time of day. It is most effective in shallow water and is, therefore, most commonly used in rivers and streams and occasionally in the shallow water zones of lakes.

Electrofishing removal would be accomplished by UDWR using multiple Smith-Root LR24 backpack electrofishing units or their equivalent from another manufacturer. Block nets of sufficient width would be set up to prevent fish emigration during removal activities. Dip nets, buckets, and live wells would also be necessary for capture and removal of brook trout (*Salvelinus fontinalis*) and capture and safe holding of CRCT.

Removal activities. Mechanical removal of non-native trout species using backpack electrofishing has been attempted in several other projects (Moore et al. 1986, Meronek et al. 1996, Thompson and Rahel 1996, Buktenica et al. 2000, Kulp and Moore 2000, Shepard et al. 2002, Peterson et al. 2004, Moore et al. 2005, Meyer et al. 2006, Earle et al. 2007). The results of these prior mechanical removal projects indicate: 1) achieving complete mechanical removal of trout in streams with the width, complexity, and number of small, heavily vegetated springs/tributaries found in East Fork Boulder Creek would be difficult; 2) success would be enhanced by implementing multiple-pass depletion removal efforts 3 to 4 times within the same year, and 3) success would be enhanced by treatment over multiple years (minimum of 2). For this UDWR project, the multi-year removal effort would involve a minimum of 5 to 6 people conducting multiple-pass removal efforts for the majority of summer and early autumn (late June to September) over a period of several years. While such removal efforts would undoubtedly cause major reductions in brook trout density and biomass, they may or may not result in complete eradication. UDWR would begin CRCT reintroduction efforts only when no brook trout are found within the project area.

The electrofishing removal by UDWR would follow the population monitoring methods used by Utah State University's Institute for Natural Systems Engineering, Utah Water Research Lab (INSE) during their Garkane-funded fish population monitoring on the Boulder Creek system (Hardy et al. 2009a, Hardy et al. 2009b). Personnel would electrofish approximately 100-meter reaches in 8.5 miles of the mainstem of East Fork Boulder Creek, West Fork Boulder Creek, and Boulder Creek along with all spring inflows and tributary streams. A block net would be placed across the upstream and downstream end of each reach to increase capture efficiency by preventing emigration. Up to 4 passes, or until no fish were collected, would be completed through each reach. Each pass would involve all personnel walking in the stream channel and on the banks while applying constant electric current to the water from at least two backpack electrofishers. All organisms within the stream would be subjected to the electric field. All non-native brook trout would be removed from the system, killed and buried. Any CRCT collected would be held in buckets/live wells and returned to the stream after completion of the 4 pass removal.

Effort. One crew would consist of at least 2 personnel using backpack electrofishers, 2 netters retrieving stunned fish, and 1 person with a bucket receiving and disposing of fish. Electrofishing batteries would be recharged using small gasoline powered generators. Based on their previous monitoring efforts, INSE estimated that in a 40 hour work week, 9 sites that were each 100 m long could be completed by a 5 to 6 person crew using the four pass methodology (C. Williams, Institute for Natural Systems Engineering, personal communication with M. Golden, Dixie National Forest, 3/12/2010). Based on this INSE estimate, for UDWR fish removal activities under the Non-chemical Treatment alternative, one removal effort on the 11.5 km mainstem stream (12.8 reaches, 900 m long) on NFS land would require approximately 512 hours (12.8 reaches times 40 hours) or 63 days (8 hours per day) to be completed by a 5 to 6 person crew using the four pass method. An additional effort of approximately 13 days would be needed to treat the 2.3 km mainstem on private property.

Because UDWR's removal activities would need to occur between late-June or early July and September to minimize access, weather, and high stream flow issues, each removal effort would be limited to approximately 20 days to be able to conduct 4 removal efforts in a single year. To be able to treat the entire mainstem stream, on NFS lands and private lands, during any one removal effort, 20 people (four 5-person crews) would be needed. For four removal efforts, this would total up to 80 days per year. As described below, UDWR may need up to 10 years of removal effort under this method.

During the UDWR's 2009 chemical treatment of East Fork Boulder Creek above King's Pasture Reservoir, 23 relatively large inflows or tributaries with permanent fish habitat were identified, along with many smaller springs and seeps capable of at least temporarily holding small fish. These tributaries and inflows varied in length from 10 m to over 750 meters. Additional inflows and tributaries that contain fish habitat are probably present in the reach below Kings Pasture and could add another 30 days or more to the estimated treatment time.

Efficiency of fish removal by electrofishing is substantially lower in certain types of habitats found in the treatment area, especially those with heavy aquatic vegetation, root wads, woody debris, and boulder fields. The time for one removal effort in these types of areas could be higher, and effectiveness could be lower. Also, in order to eliminate the possibility of fish moving between treated and untreated reaches, crews would need to operate simultaneously, which may negatively impact fish-removal efficiency, as stream bed disturbance from upstream crews would impact water clarity and visibility for downstream crews. Because of reduced removal efficiency with electrofishing as the fish removal method, the UDWR project may extend to 10 years.

Post-Fish Removal activities. Post-fish-removal activities by UDWR would be the same as those described for the Proposed Action.

Design Criteria. The following design criteria would be included in the written authorization for use of motorized vehicles off of designated routes and the special use authorization for the burial of removed fish:

1. State of Utah decontamination protocols for prevention of the spread of Aquatic Nuisance Species will be followed for all gear and personnel involved with the removal project.
2. The Forest Archaeologist will be consulted about potential locations to bury fish to avoid impacts to cultural resources.
3. Dead fish collected will be buried no closer than 300 feet from the stream and away from known camping areas to minimize bear/human interactions.
4. Access by motorized vehicles will be on National Forest System roads designated for motorized vehicle use to the extent possible. Any use of motorized vehicles off of designated routes will be minimal, and will require written Forest Service approval.
5. Trails will be used whenever possible to move from one location to another to minimize soil and vegetation disturbance and to prevent establishing new trails.
6. Sensitive plant habitat will be avoided during action implementation.
7. Personnel will ensure reach being treated is void of livestock and people not involved with the operation. Treated waters will remain open to fishing.

Actions connected to fish removal actions on NFS lands. The following parts of the UDWR project, as discussed above, are not subject to Forest Service permit requirements, and therefore are not included in the Forest Service decision. They are considered connected actions to UDWR's fish removal activities on NFS lands and thus included in the environmental analysis:

1. As described for the Proposed Action, the UDWR treatment area includes private property, including that owned by Garkane Energy; thus, this area is not under Forest Service jurisdiction.

The expectation is that under the Non-Chemical Treatment alternative, the UDWR would implement non-chemical treatment methods on non-NFS lands, as described below, although the UDWR may decide to use another method or methods to achieve the treatment objective on the private lands or not pursue treatment on the private lands. The flowing portions of the project area on private lands would undergo similar electrofishing removal by UDWR, as described for NFS lands above.

For the non-flowing portions of the project area on private lands, electrofishing would not be effective in removing brook trout from King's Pasture Reservoir or the pond in Kings Pasture. To remove brook trout from these areas without use of chemicals, UDWR would deploy experimental gill nets with many different mesh sizes at several locations and depths throughout each water body. Other studies where this method has been successful at eradicating brook trout suggest that it would take at least two and up to four seasons of semi-continuous netting to eliminate all size classes of trout from small lakes with relatively low trout densities (Knapp and Matthews 1998, Parker et al. 2001).

2. Potential recolonization from East Fork Boulder Creek would severely reduce the efficacy of removing brook trout from King's Pasture Reservoir; therefore, UDWR would need to construct a fish migration barrier in East Fork Boulder Creek on private property above King's Pasture Reservoir.

The barrier would generally consist of a small check dam constructed of boulders and large rocks, creating a vertical drop of approximately 5 ft on the downstream side. The location for the barrier would be selected by UDWR to utilize any naturally occurring drops which can be enhanced and where the stream channel and floodplain are confined to minimize the size of the structure and the amount of water impounded behind it. Barrier construction would comply with laws, regulations, and permitting requirements of the State Engineer for stream channel alteration. Barrier materials would be taken from the ground surface, near the stream. The collection of these materials would not require excavation, stream alteration, or vegetation disturbance. If sufficient material is not available on site, additional materials would be hauled to the barrier site from an approved source.

The barrier location would be selected by UDWR to minimize changes in stream gradient, hydraulic function, and water pooling. In addition, the barrier would be constructed by UDWR adjacent to existing roads where equipment access is acceptable, thus requiring little disturbance to surrounding areas. Riparian vegetation would be disturbed as little as possible during the construction of the barrier, while areas where surface disturbance would occur would be restored to pre-project conditions. The barrier would not be placed in areas of cultural or historic significance or in areas where sensitive, threatened or endangered plants occur. It would be designed to operate under the natural fluctuations of a stream flow without routine maintenance. The barrier would be designed to pose little, if any, threat to the natural stream system or its associated riparian area so that if it were to fail, no damage would result to the stream environment. UDWR's maintenance could include

the adjustment or replacement of individual rock materials, but such work would be minor. The barrier could be removed but only after treatment is determined to be fully successful.

Neither netting nor electrofishing are options for UDWR for removing any non-native trout that may be using the upper portion of the penstock inflow or the lower portion of the pipeline from the West Fork Reservoir during treatment efforts. Shutting off water to these areas until they were completely dry would be the only way to ensure complete eradication; however, this is not feasible (M. Avant, Garkane Energy, personal communication with M. Golden, Dixie National Forest, 4/1/2010). Because of this, the effectiveness of the rest of the treatment would be reduced, contributing to the likelihood of the longer period of treatment.

3. Stocking of fish by UDWR would be as described for the Proposed Action.
4. As described for the Proposed Action, fishing regulations, including whether or not treated waters would remain open to fishing, is under the jurisdiction of UDWR. The expectation is as described for the Proposed Action.

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Figure 1. Project area location

